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RESOURCE DEVELOPMENT AND TECHNOLOGY

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RESOURCE DEVELOPMENT AND TECHNOLOGY

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1. The population density of human beings on earth has now reached the point where industrialization is essential if people the world over are to lead reasonably healthy lives. The task of increasing food production alone requires the manufacture of large quantities of fertilizers, which in turn requires the fixation of nitrogen and the chemical processing of phosphate rock on a large scale. The processing must take place using equipment which requires for its fabrication steel and other metals. The fertilizers must be transported by trains and trucks, along railroads and highways which must be built.

2. The task of increasing food production also requires the manufacture and distribution of pesticides, the extension of areas of cultivated lands and the elaboration of water distribution systems. All of this requires machinery, factories, piping, pumps, chemicals and energy, which are products of an industrial society.

3. Thus, when we consider only the requirements for substantially increasing food production, we must conclude that an appreciable measure of industrialization is necessary. When we add to this the additional requirements for medical facilities and supplies, schools, adequate housing, clothing, communication and transportation, it is clear that a really substantial degree of industrialization is necessary in most areas if people are to lead healthy lives.

4. There are many quantities which can be used to indicate the degree of industrialization of a nation. Particularly useful indicators are the per-capita quantities of steel in use and the per capita annual rates of energy consumption. In industrialized societies, the per capita quantities of steel in use varies from about one ton to about ten tons per person. Per capita energy consumption varies from the expenditure of about one ton of coal (or its equivalent in some other form of energy) per person each year, to the expenditure of about ten tons of coal per person each year. In societies which are predominantly agricultural, the quantities are much lower.

5. The quantity of steel in use (or its equivalent in other substances) which is necessary to support an individual in an industrialized society is itself destined to increase with time. One important reason for this is that, as the pressures upon resources increase, greater technological effort must be placed upon the extraction of needed metals and other materials from substances of steadily lower grade. Thus, since the beginning of this century, the average concentration of copper in processed ores has decreased from several percent to about 0.5 percent. For a given quantity of copper, it is now necessary to handle much more material and to engage in much more technological processing than was necessary sixty years ago. This necessitates the use of more equipment and of greater quantities of chemicals. As a result, the quantities of steel and other metals in use increase.

6. No matter where we turn in the area of raw materials availability, we usually encounter a similar situation. Grades of metallic ores of a variety of types are decreasing. Other essential substances, water for example, are often difficult to obtain easily in adequate quantities. As a result one must dig more deeply, use more complicated processes, and transport larger quantities over greater distances. Again, this requires the use of more equipment, more materials, more steel and other metals.

7. A world population of three billion (3×10^9) persons, if industrialized, would require somewhere between 3×10^9 and 30×10^9 tons of steel in use, were its inhabitants to be provided adequately with the necessities of life and were the steel distributed evenly about the world in proportion to population. Considering the fact that many industrialized areas of the world already have considerably more than one ton of steel in use per person, and considering further the fact that the population of the world is destined to become considerably larger than it is at present, the quantity of steel eventually in use in the world is probably destined to exceed 30×10^9 tons by a considerable amount. Already the use of steel in the United States alone is approaching 2×10^9 tons. It is extremely dubious that the population of the world will stabilize at a level much less than 7×10^9 persons. Under the circumstances it is quite conceivable that the quantity of steel in use in the world may grow in the distant but foreseeable future to something of the order of 70×10^9 tons.

8. Associated with this steel in use, in the form of machinery and structures of various types, there would be vast quantities of other metals. For every ton of steel in use we must utilize about 40 pounds of copper and only somewhat smaller quantities of other metals such as lead and zinc. Thus, were 60×10^9 tons of steel actually in use, about 1×10^9 tons of copper (or its equivalent in some other type of metal) would be required as well. To this must be added the requirements for other metals.

9. In order to power an industrial society, energy equivalent to that contained in about one ton of coal is required each year for every ton of steel in use. Thus, it is quite conceivable that annual energy demands in the world may in the foreseeable future grow to the equivalent of the burning of about 60×10^9 tons of coal annually - about 30 times the present annual rate of consumption.

10. These large long-range estimates of needs for raw materials are cited primarily to illustratethat demands for raw materials in the future will almost certainly dwarf those of the present. As we approach the time when such demands are realities, we will find that supplies of high grade resources are increasingly difficult to locate - that we will be called upon to utilize resources of continually lower grade, to make use of substitute materials, and, with proper application of technology, to minimize the waste of precious substances.

11. At the present time world demands for raw materials are already increasing rapidly. Demands for minerals and metals, which more than doubled between the 1930's and the 1950's, are likely to double again by the 1970's. In Europe alone, the consumption of copper appears destined by 1970 to be double the 1955 rate. When we couple these increases with those taking place in the U.S.S.R. and Japan and in such areas as India and China, it is clear that we are on an exponentially increasing curve of demand. In view of these rapidly increasing demands for essential materials, it is likely that the grades of the sources of these materials are destined to decrease even more rapidly in the future than they have in the past.

12. It is important that we recognize these changes which confront us. At the same time, it is important that we recognize that our technological capabilities can, given

proper effort, enable us to keep pace with the demand. The technological developments which are needed in the years ahead, if we are to be supplied with adequate quantities of raw materials, fall into four broad categories:

(a) The development of improved techniques for locating and assessing the extent of deposits of high, intermediate and low grades both near the surface and at depth.

(b) The development of techniques for lessening and for recycling wastes which have long been tolerated in many countries already industrialized.

(c) The development of substitutes for materials which are in short supply.

(d) The development of improved techniques for utilizing low-grade ores.

13. In principle, there is no lower limit to the grade of ore which can be processed, provided two criteria are fulfilled. First, a satisfactory process must be developed by the scientists and engineers; second, energy must be available for the processing. Given adequate supplies of energy, almost any material in the earth's crust can be looked upon as a potential resource.

14. By way of illustration, let us look forward to the distant future when all supplies of high grade resources have disappeared, when all coal and petroleum deposits of iron, bauxite and other metallic minerals have been consumed. Fifty years ago we would have been inclined to say that, under such drastic circumstances, industrial civilization could not survive. But today we know that it would be possible, even then, for an industrial society to thrive for a very long time.

15. Ordinary igneous and sedimentary rocks contain all of the ingredients which are necessary to industry. There are no obvious barriers to developing the necessary techniques for extracting from such rocks all of the iron, aluminum, copper, zinc and other substances that we need. There are no obvious reasons why limestone, which is extremely abundant, cannot be used as the basic material for the production of liquid fuels and a variety of other complex organic chemicals. Nor are there obvious reasons why the greater part of our fresh water supplies cannot be extracted from the sea. Energy, of course, is necessary in order to carry out such processes. But the energy contained in igneous and sedimentary rocks, in the form of uranium and thorium, is more than sufficient to take care of the needs of society for fuel for an extremely long time. To this must be added the large resources of nuclear energy available in the waters of the seas.

16. Although the need for gaining our livelihood from the leanest of earth substances lies in the distant future, it is important that we understand where we are heading if we are to make proper plans and undertake adequate developments during the intervening years which lie ahead. We must recognize that we are approaching a time when, barring a world catastrophe, men the world over will gain their livelihood from the lowest common denominators of the earth's crust - air, seawater, ordinary rock and sunlight. Air will provide us, on an expanding scale, with nitrogen for agriculture. From seawater we will obtain fresh water, some metals and salts. Ordinary rocks will provide us with the majority of metals, phosphorus and carbon, and the greater part of our energy. Sunlight will continue to provide energy for agriculture and will provide as well some space heating, together with power for certain specialized purposes.

17. It will be many decades before the world as a whole will be faced with the necessity of living under such extreme circumstances. But nature has not distributed high grade resources equitably over the earth's surface. Some areas of the

world are richly endowed with certain resources; others suffer from the fact that they were not endowed with reasonably high grade deposits of critical materials. Still others were at one time rich in certain resources, but have consumed or sold them. Under the circumstances, it seems clear that the developing nations will often be faced with the necessity of applying the most advanced technology to the problems of securing and processing raw materials for their industries.

18. Many techniques for utilizing inferior materials already exist. In the absence of high grade iron ores, intermediate grade ores such as taconites can be utilized. Aluminum can be produced from clays. Copper, tin, lead, nickel and germanium can be isolated from a variety of intermediate and lowgrade deposits. Inferior grades of coal can be converted, through gassification processes, to useful fuels. But many techniques must still be developed in the years ahead if supply is to equal demand. Not only the nations presently industrialized but the nations now developing industrially also will contribute substantially to such developments.

19. Each of the developing nations should decide for itself the most effective means of utilizing its resources. Although aid from abroad can help with certain development problems, and can help accelerate the process, in the long run each nation or region must supply from within itself the major elements of industrialization. A number of nations which are endowed with large quantities of certain non-renewable resources can trade those resources for equipment for basic industries, thus enabling those nations which are at present best able to convert resources into products, to produce the needed goods. Often this can be done without jeopardizing the nation's own development program, for by the time the given resource is depleted the new technology which has arisen during the intervening period can permit the industrialization process to continue. But in all such cases it must be kept in mind that high-grade resources are in fact valuable high-grade capital assets and that sooner or later they will disappear. Funds derived from their sale should be converted to other forms of capital, which are of equal or greater value, particularly into basic industrial installations and into power, transportation and communication systems. The conversion of high-grade resource assets into current living expenses by means of export can be a tragedy.

20. Naturally, it makes economic sense for the world industrial community to feed upon high grade resources for as long a time as possible. The greater the depositss of high grade resources which can be uncovered, the more rapid will be the development process and the easier will be the transition from high to low grade resources which lies ahead. For this reason, it is important that expanded technological effort be placed upon the development of techniques of surveying and mapping, of locating deposits and of estimating their extent. It is probable that substantial deposits of coal, petroleum and metals remain to be discovered in many areas of the world.

21. The lifetimes of our high-grade resources can also be prolonged if we can learn to utilize them more efficiently and to lessen wastes which have long been tolerated in many countries already industrialized. Losses resulting from failure to recycle scrap efficiently, from corrosion, from obsolescence, from failure to reclaim sewage, from excessive use of materials such as water, can be decreased by proper application of technology - particularly iffsuch factors are taken into account in the planning of new urban areas and industrial complexes.

22. Local shortages of raw materials can often be alleviated by the utilization of substitute materials. Already we have seen a variety of synthetic fibers replace silk, wool and cotton; copper can be replaced by aluminum in high tension wires; in certain areas, sulfuric acid has been replaced by hydrochloric; aluminum has bee

used in place of steel; uranium can be used in place of coal. In the years ahead, we will probably see many more substitutions such as fiberglass-plastic laminates replacing steel and sunlight replacing coal and oil for space heating.

23. In principle, man has at his disposal ample material resources to permit him to provide adequately for his population for a very long time to come. Yet to develop the technology which will make this possible will not be easy, and to apply it will be even more difficult because of the enormous social, economic and political factors involved. But the technological problems of resource development, at least, appear to be soluble - given reasonable effort.

24. Specific technological problems involving resources will vary from nation to nation and from region to region. Each developing nation should prepare itself to solve the technological aspects of those resource problems which are peculiar to it. This means that it must create research and development laboratories and staff them with competent scientists, engineers and technicians.

25. Many developing nations, however, have numerous problems in common involving resource development. Often these problems are not being worked on today - in part because of lack of facilities in the developing nations themselves, and in part because the presently developed nations are not themselves confronted by these problems. Under the circumstances, it would seem reasonable to consider the creation of one or more international laboratories which would deal with general resource development problems intensively and on a large scale. Such laboratories or institutes could be staffed by scientists and engineers from both developed and developing regions of the world. It would be a beginning, leading hopefully to world-wide technological collaboration on an ever-expanding scale.

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